

1 CLAIMS

What is claimed is:

1. A method for determining an orientation of an object, the method comprising:
- acquiring an intensity image of the object;
 - generating at least a portion of a two-dimensional frequency response of the intensity image;
 - representing the at least a portion of a two-dimensional frequency response within a frequency space, the at least a portion of a frequency response providing features arranged in a spatial-frequency pattern within the frequency space; and
 - finding an orientation of the spatial-frequency pattern within the frequency space, thereby providing the orientation of the object.
2. The method of claim 1, wherein the intensity image is of a portion of the object.
3. The method of claim 1, wherein generating further includes:
- generating at least a portion of a two-dimensional frequency response of the intensity image by applying a frequency analysis tool to the intensity image.
4. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:
- generating at least a portion of a magnitude of a two-dimensional discrete Fourier transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.
5. The method of claim 4, wherein the two-dimensional discrete Fourier transform includes a two-dimensional discrete fast Fourier transform.
6. The method of claim 3, wherein generating the at least a portion of a two-dimensional frequency response of the intensity image includes:
- generating at least a portion of a two-dimensional discrete cosine-transform of the intensity image to provide the at least a portion of a two-dimensional frequency response.

- 1 7. The method of claim 3, wherein generating the at least a portion of a two-
2 dimensional frequency response of the intensity image includes:
3 generating at least a portion of a two-dimensional discrete sine-transform of the
4 intensity image to provide the at least a portion of a two-dimensional
5 frequency response.
- 1 8. The method of claim 3, wherein generating the at least a portion of a two-
2 dimensional frequency response of the intensity image includes:
3 generating at least a portion of a two-dimensional z-transform of the intensity
4 image to provide the at least a portion of a two-dimensional frequency
5 response.
- 1 9. The method of claim 1, wherein representing further includes:
2 representing the at least a portion of a two-dimensional frequency response as a
3 logarithmically scaled frequency response within the frequency space.
- 1 10. The method of claim 1, wherein the frequency space is a frequency image, and
2 wherein representing the at least a portion of a two-dimensional frequency
3 response further includes:
4 scaling the at least a portion of a two-dimensional frequency response using a
5 scaling function so as to enhance high frequency responses within the at
6 least a portion of the two-dimensional frequency response to provide a
7 scaled frequency response; and
8 mapping the scale response by gray scale on the frequency image.
- 1 11. The method of claim 1, wherein finding further includes:
2 applying an angle finding means to the frequency space to provide an angle of the
3 spatial-frequency pattern.
- 1 12. The method of claim 1, wherein finding further includes:
2 identifying the spatial-frequency pattern within the frequency space; and
3 finding the orientation of the spatial-frequency pattern.

- 1 13. The method of claim 1, wherein the at least a portion of a two-dimensional
2 frequency response provides features forming a plurality of spatial-frequency
3 patterns within the frequency space, and wherein finding further includes:
4 finding the orientation of the plurality of spatial-frequency patterns.
- 1 14. The method of claim 1, wherein the at least a portion of a two-dimensional
2 frequency response provides features forming a plurality of spatial-frequency
3 patterns within the frequency space, and wherein finding further includes:
4 identifying one dominant spatial-frequency pattern from among the plurality of
5 spatial-frequency patterns; and
6 finding the orientation of the dominant spatial-frequency pattern.
- 1 15. The method of claim 14, wherein identifying further includes:
2 identifying as the dominant spatial-frequency pattern one spatial-frequency
3 pattern of the plurality of spatial-frequency patterns that includes a
4 greatest number of the features.
- 1 16. The method of claim 1, wherein the orientation is at a constant offset from the
2 orientation of the spatial-frequency pattern.
- 1 17. The method of claim 16, wherein the constant offset substantially equals zero.
- 1 18. The method of claim 16, wherein the orientation of the object is defined by an
2 orientation angle of a feature on the object.
- 1 19. The method of claim 1, wherein the spatial-frequency pattern includes a line, the
2 line having a line angle, and wherein the orientation of the object is an object
3 angle, the object angle having a constant offset from the line angle.
- 1 20. The method of claim 19, wherein the object is a leaded object having leads, and
2 wherein the orientation of the leaded object is defined by an orientation angle of
3 one of the leads.
- 1 21. The method of claim 19, wherein the object angle substantially equals an
2 orientation angle of a surface mount object from an axis of the intensity image.
- 1 22. The method of claim 1, further comprising:

inputting the orientation of the object into a subsequent image processing algorithm.

23. A method for determining an orientation of an object, the method comprising:
acquiring an intensity image of the object;
generating at least a portion of at least a two-dimensional frequency response of
the intensity image, frequencies within the at least a portion of at least a
two-dimensional frequency response forming a spatial-frequency pattern;
finding an orientation of the spatial-frequency pattern, thereby providing the
orientation of the object.
24. The method of claim 23, wherein generating further includes:
representing the at least portion of at least a two-dimensional frequency response
within a frequency space, features within the frequency space forming the
spatial-frequency pattern.
25. The method of claim 24, wherein the frequency space is a frequency image, and
wherein representing the at least a portion of at least a two-dimensional frequency
response further includes:
scaling the at least a portion of at least a two-dimensional frequency response
using a scaling function so as to enhance high frequency responses within
the at least a portion of the two-dimensional frequency response to provide
a scaled frequency response; and
mapping the scale response by gray scale on the frequency image.
26. The method of claim 23, wherein generating further includes:
generating at least a portion of at least a two-dimensional frequency response of
the intensity image by applying a frequency analysis tool to the intensity
image.
27. The method of claim 26, wherein generating the at least a portion of at least a
two-dimensional frequency response of the intensity image includes:

3 generating at least a portion of a magnitude of at least a two-dimensional discrete
4 Fourier transform of the intensity image to provide the at least a portion of
5 at least a two-dimensional frequency response.

1 28. The method of claim 23, further comprising:
2 acquiring a plurality of intensity images of the object at different depths within
3 the object; and
4 generating a three-dimensional image containing a three-dimensional intensity
5 representation of the object using the plurality of intensity images of the
6 object;

7 wherein generating the at least a portion of at least a two-dimensional frequency
8 response of the intensity image further includes:

9 generating at least a portion of a three-dimensional frequency response by
10 applying a frequency analysis tool to the three-dimensional image.

1 29. The method of claim 23, wherein the orientation of the object in the intensity
2 image is at a constant offset from the orientation of the spatial-frequency pattern
3 in the frequency space.

1 30. The method of claim 29, wherein the orientation of the object is defined by an
2 orientation angle of a feature on the object.

1 31. The method of claim 23, wherein the spatial-frequency pattern includes a line, the
2 line having a line angle, and wherein the orientation of the object is an object
3 angle, the object angle having a constant offset from the line angle.

1 32. An apparatus for determining an orientation of an object within an intensity
2 image, the apparatus comprising:
3 frequency means adapted to generate at least a portion of at least a two-
4 dimensional frequency response of the intensity image;
5 a frequency space adapted to receive the at least a portion of at least a two-
6 dimensional frequency response, the at least a portion of a frequency
7 response providing features arranged in a spatial-frequency pattern within
8 the frequency space; and

- 9 finding means adapted to find an orientation of the spatial-frequency pattern
10 within the frequency space, thereby providing the orientation of the object.
- 1 33. The apparatus of claim 32, wherein the frequency means is further adapted to
2 generate at least a portion of at least a two-dimensional frequency response of the
3 intensity image by applying a frequency analysis tool to the intensity image.
- 1 34. The apparatus of claim 33, wherein the frequency means is further adapted to
2 generate at least a portion of a magnitude of at least a two-dimensional discrete
3 Fourier transform of the intensity image to provide the at least a portion of at least
4 a two-dimensional frequency response.
- 1 35. The apparatus of claim 32, wherein the frequency space is a frequency image, the
2 apparatus further comprising:
3 scaling means, adapted to scale the at least a portion of at least a two-dimensional
4 frequency response on the frequency space using a scaling function so as
5 to enhance high frequency responses within the at least a portion of the
6 two-dimensional frequency response and to provide a scaled frequency
7 response; and
8 mapping means, in cooperation with the scaling means, adapted to map the scaled
9 frequency response by grey scale on the frequency image.
- 1 36. The apparatus of claim 32, wherein the orientation of the object in the intensity
2 image is at a constant offset from the orientation of the spatial-frequency pattern
3 in the frequency space.
- 1 37. The apparatus of claim 36, wherein the orientation of the object is defined by an
2 orientation angle of a feature on the object.
- 1 38. The apparatus of claim 32, wherein the spatial-frequency pattern includes a line,
2 the line having a line angle, and wherein the orientation of the object is an object
3 angle, the object angle having a constant offset from the line angle.
- 1 39. A method for finding an orientation of an object, the method comprising:
2 acquiring an intensity image of the object;

3 applying a frequency analysis tool to the intensity image to produce at least a
 4 portion of a two-dimensional frequency response of the intensity image;
 5 representing the at least a portion of a two-dimensional frequency response within
 6 a frequency space, the at least a portion of a frequency response providing
 7 features arranged in spatial-frequency pattern within the frequency space;
 8 and
 9 determining an orientation of the spatial-frequency pattern to provide the
 10 orientation of the object.

1 40. The method of claim 39, wherein applying the frequency analysis tool includes:
 2 generating at least a portion of a magnitude of a two-dimensional discrete Fourier
 3 transform of the intensity image to provide the at least a portion of a two-
 4 dimensional frequency response.

1 41. The method of claim 39, wherein the frequency space is a frequency image, and
 2 wherein representing the at least a portion of a two-dimensional frequency
 3 response further includes:
 4 scaling the at least a portion of a two-dimensional frequency response using a
 5 scaling function so as to enhance high frequency responses within the at
 6 least a portion of the two-dimensional frequency response to provide a
 7 scaled frequency response; and
 8 mapping the scale response by gray scale on the frequency image.

1 42. The method of claim 39, wherein the orientation of the object in the intensity
 2 image is at a constant offset from the orientation of the spatial-frequency pattern
 3 in the frequency space.

1 43. The method of claim 42, wherein the orientation of the object is defined by an
 2 orientation angle of a feature on the object.

1 44. The method of claim 39, wherein the spatial-frequency pattern includes a line, the
 2 line having a line angle, and wherein the orientation of the object is an object
 3 angle, the object angle having a constant offset from the line angle.